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Optimization Opportunity for Mine Ventilation and Cooling Plant System at Maddahapara Granite Mine, Dinajpur, Bangladesh

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Abstract—**Mine ventilation optimization and air flow management are two obligatory features of mine ventilation system. However, blasting creates lots of poisonous and harmful gases during mining operation. Additionally, mine worker faces obstacle due to the presence of fume and poisonous gas. This research work founds that Maddhapara ventilation system losses 20% of air on various circumstances. This involves the prevention of unwanted circumstance to deliver a sustainable working environment and provide a scientifically proven scheme to prevent mine hazards. The outcome of this research optimizes the ventilation system in Maddahapara Granite Mine which increases air flow rate by installing an air-cooling plant. Maddahapara mine ventilation system should be optimized and controlled by using mine ventilation doors and maintenance of ventilation equipment.**

Keywords—Optimization, ventilation improvement, poisonous gas, controlling air flow, Temperature controlling

I. INTRODUCTION

Maddahapara Granite Mine (MGM) is the unaccompanied one underground jointly jump handle in Bangladesh under the Petrobangla and the Ministry of Power, Energy and Mineral Resources of Bangladesh [1]. MGM is controlling in Maddahapara, Dinajpur sector, northwest Bangladesh, with an outlook of virtually 1.44 km², mid latitude 25º23´22´´ N and 25º34´43´´ N and longitude 89º03´34´´ E and 89º05´04´´ E. In 1974, Geological Survey of Bangladesh (GSB) ran an exploration skim in Maddahapara [2]. In the Maddahapara trend, basement rock is encountered at a depth of 130 m [3]. An estimated ace in the hole of 174 million tons of jointly rock in MGM consisting of granodiorite, diorite, quartz-diorite and gneiss of the Pre-Cambrian latter part of animate life has been discovered. Mining is a major economic reaction in many economically developing country [4,5]. The mining rule of thumb applied in MGM is room and pillar/ sub-level stopping methods. There are 5 stopes under concept of which two are in the south and three are in the north. The term, height, width and length of each stope are 230 m, 60 m and 20 m, respectively. The invent hole drilling is secondhand in MGM and fan knee-jerk reaction is secondhand for blasting operation. Ammonium Nitrate Fuel Oil (ANFO) and power gel are secondhand for blasting purpose. The work of genius of granite is ~1.65 million tons/yr. Mine operations, whether smaller pervasive, are inherently raucous to the environment [2,6]. The environmental deterioration caused by mining occurs especially as a show once and for all of incongruous and wasteful engrossed practices and rehabilitation measures. Mining has an abode of hack stages or activities, each of which has potentially-adverse impacts on the intuitive environment, crowd and cultural heritage, the brute force and conservation of employ workers, and communities based in complete proximity to operations [7,8,12]. The circumstance of this Granite in the rough is to engage out the environmental impacts caused by the fraud of strictly rock in MGM and its accessible remedies and minimization to derive MGM a sustainable mine apprehension. Bangladesh has become a rapid rising country which is facing the problems of both groundwater superiority and extent. Increasing urbanization, population of explosion and exhaustive are the problem contributing factors on agriculture sectors. The Sagardari union, the main studied area, is required to use 50% of its water prerequisite from groundwater resources. The unlined drains which is opened and the removal of pollution in different locations in the recharge extents act as pollution source of groundwater [5].

II. VENTILATION SYSTEM AT MADDAHAPARA

Exhausting ventilation system is used in the Maddahapara mine ventilation System. Different elements of exhausting ventilation system are showed in figure 2,3.

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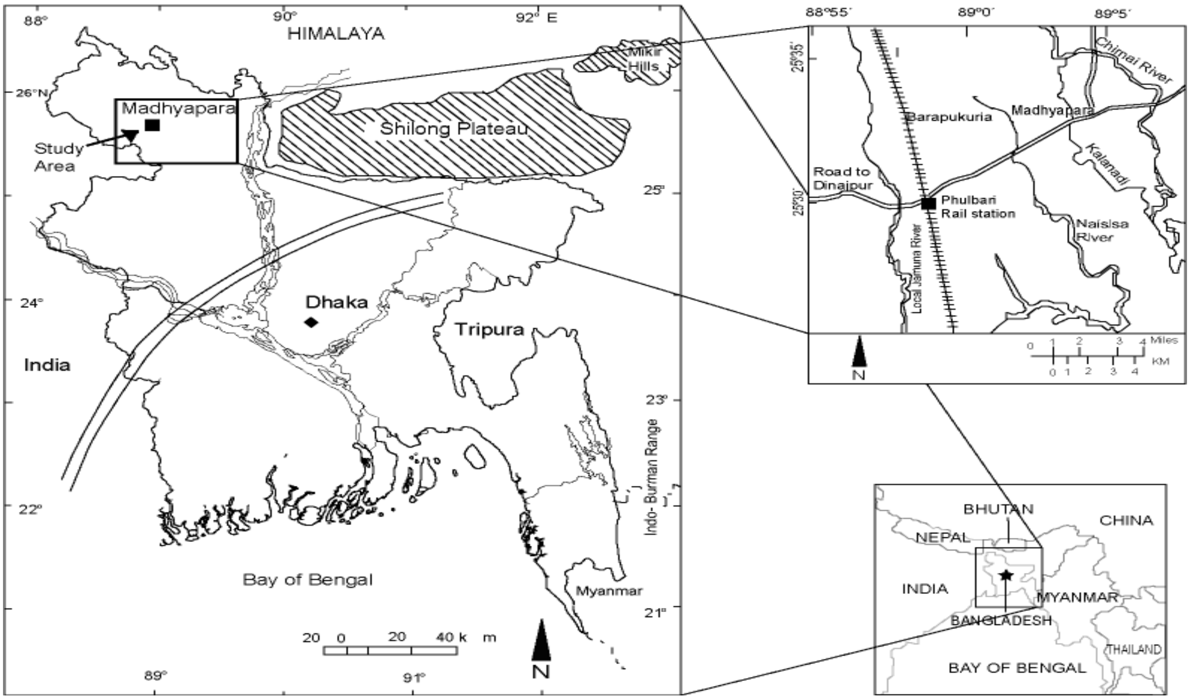
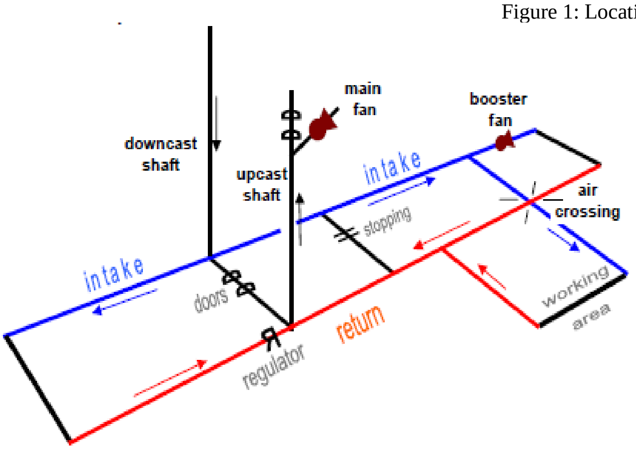


Figure 1: Location of the study area [2]



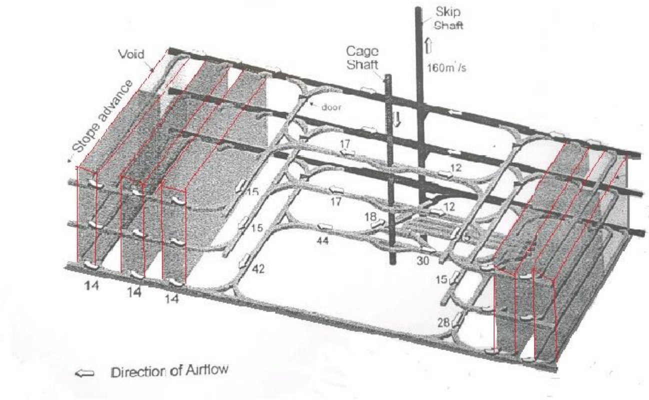


Figure 2: Exhausting ventilation system underground mine [6]   Figure 3: Maddhapara ventilation lay-out and air flow direction

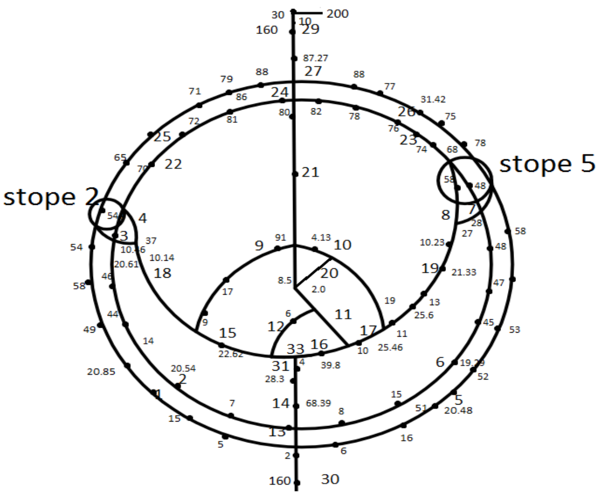


Figure 4: Maddahapara ventilation network data analysis diagram

III. METHODOLOGY

The quantity of air passing through any airway every second, Q is generally given by the expression [4,9,10,11]

$$Q = U \times A \ (m^3/s)$$

Where,

U = Velocity of air passing through that point (m/s)

A = Area of roadway (m^2)

Thus, to calculate the quantity of air flowing past any measuring station, it is necessary

a) To ascertain the cross-sectional area of the passage =A m^2.

b) To measure the velocity of air current= V (m/s)

The air flow measuring point showing at figure 4.

IV. RESULT AND DISCUSSION

Maddahapara ventilation fan capacity 200 $m^{3/}$s. But we have found 160 m^3/s air flows in the ventilation survey. Based on analysis result, the air loss amount 20 % which is the large amount are shown in table 1 and table 2. In the internationally air flow loss 5% allow in ventilation system.

A. Causes of Air Flow Loss

The causes of air flow losses are described below

***A**.1 Auto Compression*

Auto compression is the increase in air temperature with depth resulting from the weight of the column compressing the air. This is generally expected as 10°C (dry bulb) per 1000 m. Based on this air delivered to the 220m level will increase by 3.0° C.

A. 2 Explosives

Only 5% of the energy produce by blasting is used to break the rock, the remaining 95% is released as heat. For many years it was thought that this heat was dissipated directly to the ventilation system and removed during the re-entry period. It is now more widely accepted that this heat is transferred to the broken rock and liberated over a much longer period which is variable and dependent upon ventilation and rock surface exposure.

There has not been any attempt to quantify this head load. The importance of this rate is to raise awareness for design of ventilation circuits to ensure,

- Stop draw points up cast, taking heat away from loading operations.
- That airflow to the charging level is directed first over personnel working on the level and then over the rock pile directly to exhaust.

A. 3 Machinery

All machinery has inefficiencies converting input energy into mechanical output, this results in heat loss to the environment. The general principle applied is that all electrical energy consumed is converted to either heat energy, or useful work, which is only achieved by raising the potential energy of an object to a higher elevation against the force of gravity. For example, fans do not do any useful work and all energy into output into the motor is converted to heat energy. There has not been any attempt to calculate the heat load at Maddahapara and is outside the scope of this review. The importance of this note is to raise awareness of potential heat sources that are in the intake air circuit. For example, pump stations and electric locomotives.

A. 4 Workplace Temperatures

Table 4 -data shows that when workplace temperature 28°C then the surface ambient temperature rises above 26°C wet bulb Until a more thorough investigation of surface climate data and underground heat loads is completed. It is noted that this procedure has been develop for workers wearing lightweight cotton clothing [11,12]. During the site visit, it was noted that underground employees were wearing plastic waterproof clothing. The need for this type of clothing must be reassessed as it prevents the evaporation of sweat from the body, which is necessary to assist cooling. In the view of proposed work practice, a design ACP of 200 w/m^2 is considered optimum with modified working times occurring when the cooling power of the air falls below 140 w/m^2. To assist with this determination the cooling power charts (table 3), should be used. As the mine extends and the residence time of airflow through the circuit increase, the heat transfer from the rock to the airflow will also increase [11]. As a result of this it could reasonably be expected that wet bulb temperatures would exceed 32° C during the hottest period of the year.

B. Proposed Optimized Air Flow

Based on the inspection result the total mine airflow is determined to be 160 m^3/s. Due to expected high leakage component of an extended mine, these velocities may be difficult to maintain. The result of lower air velocity will be an increase in Workplace temperatures. Based on Maddahapara Granite Mine Physiological parameters, surface meteorological parameters, geological parameters, production and mining parameters there are three possible options -

- Increase mine air flow
- Install an air-cooling plant
- Both Increase mine air flow and Install an air-cooling plant

As the mine shafts will be operating at the maximum recommended velocities, any increase in air- flow will require the development of an additional shaft. Cooling power concepts need to be introduced with caution as the vast majority of studies have been conducted on essentially nude male South Africa miners. Further studies have provided an allowance for clothing that again has its origins in South Africa mines and is dependent upon material type. Again, it is noted the wearing of waterproof clothing shields any benefit that may be provided by air velocity. The optimum economic velocities that are applied for the purpose of ACP are invariably between 0.5 m/s and 1.5 m/s but mostly between 0.75 m/s and 1.0 m/s. It is noted that the effectiveness of air velocity improving ACP is diminished by the practical difficulties of increasing airflow to workplace.

B.1 Ventilation Doors and Controls

To provide the proposed ventilation circuits will require the installation and maintenance of many doors, regulators and seals. The ultimate effectiveness of these controls will dictate the ambient conditions in the production and development areas.

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Table 1: Data analysis of ventilation in Production level of Maddahapara granite mine

Level	Position of inspection	Design amount (m^3/s)	Cross-section (m^3)	Velocity (m/s)	Air Amount (m^3/s)	Air amount error ($\pm m^3/s$)
Pro-Level	North inlet in cage	59.4	12.23	4.91	60.04	+0.64
	South inlet in cage	42.6	13.17	3.75	49.38	+6.78
	Intake amount in cage shaft	102				
	Drift into mine car repairing shop	14.4	6.5	2.61	16.97	+2.57
	Main Pump	6	3.63	1.80	6.54	+0.54
	Roadway in N-E loop	24.4	6.46	4.65	30.03	+5.63
	Roadway in N-W loop	16.6	6.46	3.58	23.13	+6.54
	Roadway in S-W loop	17.6	7.6	3.20	24.32	+6.72
	Roadway in S-E loop	19	7.43	3.85	28.61	+9.61
	Roadway air -door-2 in N2	20.4	4.715	4.25	20.04	-0.36
	Roadway air -door-1 in S2	17	4.715	4.65	21.93	+4.93
	Air-door-27 on boulder crusher in unloading chamber	6	0.62	12.70	7.88	+1.88
	N shunt in roadway to unloading chamber	4	6.67	2.58	17.20	+13.20
	Stope-1(N.E)	8.17	6.5	1.50	9.75	+1.58
	Stope-1(N.W)	6.68	7.6	0.75	5.7	-0.98
	Stope-1(Drill drift)		7.27	0.63	4.58	+4.58
	Stope-2(N.E)	6.27	6.5	1.00	6.5	+0.23
	Stope-2(N.W)	5.23	7.5	0.72	5.4	+0.17
	Stope-2(Drill drift)		7.3	0.65	4.75	+4.75
	Stope-3(N.E)	5.85	6.5	1.27	8.26	+2.40
	Stope-3(N.W)	4.79	7.6	0.80	6.08	+1.30
	Stope-3(Drill drift)		6.9	0.36	2.50	+2.50
	Stope-4(S, E)	8.86	7.2	2.20	15.85	+6.98
	Stope-4(S, W)	9.42	7.42	1.52	11.28	+1.86
	Stope-4(Drill drift)		7.24	1.20	8.69	+8.69
	Stope-5(S, E)	8.03	6.77	1.55	10.50	+2.47
	Stope-5(S, W)	8.18	7.5	1.3	9.75	+1.57
	Stope-5(Drill drift)		7.3	0.8	5.84	+5.84
Skip - Tower	+31.2m Level	30.0	8.7	Average 7.30	63.51	+33.51

Table 2: Data analysis of Ventilation In -vent and Sub-Level of Maddahapara granite mine

Level	Position of inspection	Design amount (m^3/s)	Cross section (m^2)	Velocity (m/s)	Air Amount (m^3/s)	Air amount error ($\pm m^3/s$)
Ventilation Level	North inlet in cage	14.4	10.56	1.62	17.11	+2.71
	South inlet in cage	9.6	10.56	1.50	15.84	+6.24
	Outlet amount in N-E loop	35.26	7.53	6.25	47.06	+11.8
	Outlet amount in S-E loop	27.63	7.55	5.30	40.02	+12.39
	Total outlet amount in Vent-level	62.89			120.03	+57.14
	Wing-door-31 in S-W roadway	9.6	1.84	10.10	18.58	+8.98
	Wing-door-32 in N-W roadway	14.4	2.03	8.10	16.44	+2.04
	Stope-1	5.57	8	1.10	8.8	+3.23
	Stope-2	4.57	7.56	0.91	6.88	+2.31
	Stope-3	4.35	7.94	1.70	13.5	+9.15
	Stope-4	4.95	6.45	1.50	9.68	+4.73
	Stope-5	4.62	7.45	1.70	12.67	+8.05
Sub-Level	North inlet in cage	14.4	10.41	1.40	14.57	+0.17
	South inlet in cage	9.6	10.58	1.40	14.81	+5.21
	Outlet amount in N-E loop	34.27	7.2	5.50	39.6	+5.33
	Outlet amount in S-E loop	26.43	7.1	4.10	29.11	+2.68
	Total outlet amount in Vent-level	60.7	10.4		98.09	+37.39
	Wing-door-29 in S-W roadway	9.6	1.65	10.30	17	+7.40
	Wing-door-30 in S-W roadway	14.4	2.03	7.70	14.21	-0.19
	Stope-1	5.49	8.50	1.08	9.18	+3.69
	Stope-2	4.55	8.42	1.10	9.26	+4.71
	Stope-3	4.33	8.56	1.35	11.57	+7.24
	Stope-4	4.99	8.58	2.10	18.02	+13.03
	Stope-5	4.67	9.7	1.45	14.07	+9.40

Table 3: Estimation on mean Summer temperature of Maddhapara Granite-Mine

					CASE-1			CASE-2			CASE-3		
Location	RL Relative to sea level(m)	Barometric Pressure Kpa	VRT (°C)	Airflow (m^3/s)	T_{WB} (°C)	T_{DB} (°C)	ACP (w/m^2)	T_{WB} (°C)	T_{DB} (°C)	ACP (w/m^2)	T_{WB} (°C)	T_{DB} (°C)	ACP (w/m^2)
Sea level	0	101.325											
Surface	32	100.948	27.2	160	26.0	32.0	-	27.0	33.0	-	29.0	35.0	-
Case-Shaft	-228	104.008	32.9	115	27.0	32.7	280	28.0	33.8	264	30.0	35.7	235
Case-Shaft	-270	104.502	33.4	70	27.1	32.8	283	28.1	33.8	256	30.1	35.7	227
Case-Shaft	-270	104.502	34.0	-	27.2	32.9	256	28.2	33.9	243	30.2	35.8	216
Drill & Blast	-228	104.008	32.9	14.0	28.7	33.0	220	29.6	33.7	211	31.2	34.8	191
Drill & Blast	-246	104.220	33.4	14.0	28.9	33.2	218	29.7	33.8	209	31.4	35.1	189
Production	-270	104.502	34.0	10.0	29.6	34.6	200	30.4	35.2	191	31.9	36.2	166
	-270	104.502	34.0	20.0	28.5	32.4	231	29.4	33.1	222	31.2	34.7	199

Table 4: Dry bulb temperature of Maddhapara Granite-Mine

		WET BULB ° C											
		24	25	26	27	28	29	30	31	32	33	34	35
DRY BULB ° C	40	168	163	158	154	149	144	139	131	120	108	95	81
	39	172	167	162	157	153	148	142	133	122	110	97	83
	38	175	170	166	161	156	152	145	136	124	112	99	85
	37	179	174	169	165	160	156	148	138	127	114	101	87
	36	183	178	173	169	164	159	150	140	128	116	102	88
	35	185	182	177	173	168	162	153	143	130	117	104	90
	34	188	185	181	177	172	165	156	145	132	120	106	
	33	191	188	184	181	176	168	158	147	134	121		
	32	194	191	187	184	179	170	160	149	136			
	31	197	194	190	187	182	173	162	150				
	30	200	197	193	190	184	175	164					
	29	203	200	196	192	186	178						
	28	206	203	199	193	187		Optimum			200 w/m^2		
	27	209	205	201	195			Caution			175 w/m^2		
	26	212	208	203				Modified			140 w/m^2		
	25	215	210					Stop			115 w/m^2		
	24	218											
		24	25	26	27	28	29	30	31	32	33	34	35

Consideration should be given to the following point:

- Airlock doors must be designed to restrict airflow to between $2m^3/s$ and $4m^3/s$ with only one door closed.
- Doors will be required at both ends of the loading drives of each stope on the 270m level. These doors should allow for the control of airflow through these drives the anticipated range of flow would be form $0.0\ m^3/s$ to $10.0m^3/s$.
- Controls for airflow to stopes should be located on the intake (fresh air), side of the stope. This would enable the setting of these controls after blasting without the necessity to enter the blasting gases.
- All stope draw-points should be sealed once loading is complete.

B.2 Maintenance of Ventilation Equipment

- Operation of main fan should be definitely conduct as per operation manual and the status of maintenance should be recorded operation dairy should be logged regularly and left with the signatures of handover and takeover.
- It is principle to conduct maintenance on rest day and may be one of the two fans can be operated as per decision of personal in charge in mine.
- Ventilation department of mine should always control the condition of installation, operation and maintenance of local fan installed in the underground and log in details on the equipment logbook regarding their maintenance.
- As the air intake is conducted through case shaft, the case, in need of stoppage, should be parked in production level to avoid any hindrance to intake.
- Main Fan should be stopped only as per instruction of personal in charge of mine and record the relevant reason, stop time and the time lapsed in the logbook.

V. CONCLUSION

The mine ventilation streamlining, wind current control are the mine ventilation framework's two critical angles, great ventilation enhancement configuration can convey natural air to build up sustainable workplace and give a logical and dependable premise to forecast danger. The bound for the airflow quantity and the regulated quantity and so on as constraint condition, can be satisfied the ventilation demand and the working condition, causes the expense which the mine ventilation needs to be least, thus is suitable in solving each kind of mine ventilation network optimization adjustment question. Maddhapara mine ventilation optimize, if should be installed cooling plant or increasing air flow in the mine. Thus, install ventilation doors, regulator doors, seal doors and maintenance the ventilation equipment also optimize and controlling the Maddhapara ventilation system.

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